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Conference paper

Ultimate tensile strength of total and self-etch adhesives: Effect of light irradiation distance.

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Abstract: Objective: To evaluate the ultimate tensile strength (UTS) of total and self- etch adhesives irradiated at different distances. Materials and Methods: Sixty cylindrical specimens of 0.78mm diameter and 10 mm length were prepared of two types of adhesive systems total etch Excite DSC (EX – Ivoclar Vivadent, Schaan, Liechtenstein) and one-step self-etch Clearfil S3 Bond (S3, Kuraray Medical Inc., Tokyo, Japan). Specimens of each adhesive were divided into three groups according to the light irradiation distance (0, 2, 4mm) (n=10). Each specimen was attached to universal testing machine (Digital Force Gauge, IMADA CO., LTD, Japan) and loaded at cross head speed of 1mm/min until failure. Data were analyzed using two-way ANOVA and Independent Student t-test at $p< 0.05$. Results: Mean UTS for total etch (24.63, 18.19, 17.26 Mpa) and for self-etch (12.68, 8.53, 7.58Mpa) at (0, 2, 4mm) distances. Specimens irradiated directly show significantly the highest UTS while those irradiated at 4mm show the lowest values ($p<0.05$). Excite DSC total etch adhesive have higher UTS than Clearfil S3 self-etch adhesive regardless of irradiation distance ($p<0.05$).Conclusions: The UTS of the evaluated adhesives was light irradiation distance and adhesive system dependant.

Keywords: Light-Curing of dental adhesives; dental bonding; adhesives; mechanical phenomena; tensile strength.

INTRODUCTION.

Light intensity diminishes as the light source moves away from surface due to light scattering. However in clinical situations in which there is a cavity design like in deep class II box or in endodontically treated teeth polymerization of the dental adhesives applied over cavity wall and floor in close light tip position is impaired. Even in laboratory studies most researchers evaluate the adhesives properties through direct application of light guide.[1]

Advancements of dental adhesives have replaced classical multi-steps with simplified single-step systems available in etch and rinse self-priming or self-etching priming systems. Both are more hydrophilic versions of their multiple-step precursors with different types and concentrations of the solvents constituents. Caution should be paid to the sufficient polymerization of hydrophilic adhesive containing 2-hydroxyethyl-methacrylate (HEMA) in order to achieve an adequate level of physico-mechanical properties

Conflict of interests: No conflict of interests.

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prior to application of the restoration. Production of less hydrophilic monomer glycerol-dimethacrylate (GDMA) to replace HEMA has been attempted, in order to provide better polymerization and mechanical properties.[2] Adhesive mechanical properties and the quality of bond strength are interplaying factors. High adhesive cohesive strength is crucial at the moment of resin composite curing, because it needs to be strong enough to contra-balance the stress generated due to polymerization shrinkage.[3]

The information on the effect of photo-irradiation distance on the mechanical properties of simplified adhesives is limited.

The null hypotheses tested were that there is no effect of different irradiation distances on ultimate tensile strength (UTS) of simplified adhesives and no differences between the two types of adhesive systems (total and self-etch). Therefore the objective of this study was to evaluate the UTS of total etch and self-etch adhesives irradiated at different distances.

MATERIALS AND METHODS.

Specimen preparation for UTS

Sixty micro-capillary glass tubes of 0.78mm internal diameter were filled with two types of simplified adhesive systems equally up to 10mm. Total etch Excite DSC (EX – Ivoclar Vivadent, Schaan, Liechtenstein) and one step self-etch Clearfil S^3 Bond (Kuraray Medical Inc., Tokyo, Japan). Each adhesive was divided into three groups (n=10).

G1 filled tubes received direct irradiation; G2 were irradiated at 2mm distance through a single mould of rectangular hole (1mm width x 2mm thick x 10mm length). G3 was irradiated as G2 but using double moulds to obtain a 4mm distance.

Light curing unit of 10mm tip (XL 3000, 3M ESPE; St Paul, MN, USA) was used to polymerize specimen for 20´s at intensity >500mW/cm^2. Specimens were carefully pushed out from the tube and stored for 24 hours in water at 37°C

UTS Measurement

Specimens were attached to an universal testing machine (Digital Force Gauge, IMADA CO., LTD, Japan) and loaded at cross head speed of 1mm/min until failure. The maximum load divided by cross-sectional area of specimen was used to give UTS in MPa.

Statistical analysis

Data were analyzed using two-way ANOVA and Tukey's HSD multiple comparison test. Independent Student t-test was used to evaluate the differences between two types of adhesives at each irradiation distance $p<0.05$.

Statistics analysis were performed using Statistical Package for Social Science (SPSS for windows, version 18n SPSS Inc., Chicago, IL, United States).

RESULTS.

Mean UTS of both adhesives polymerized at different irradiation distances are show in the Figure 1.

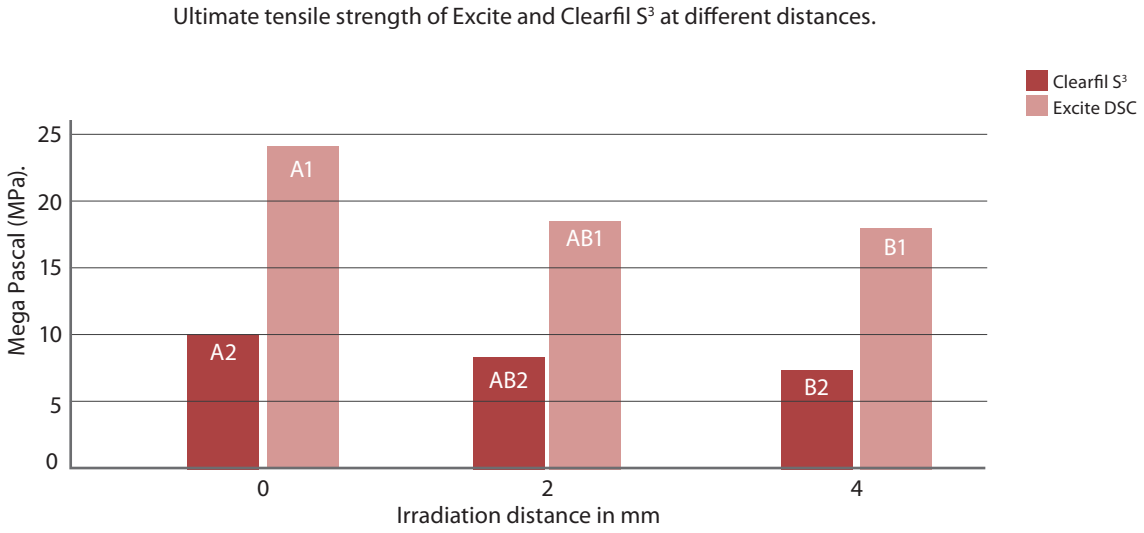
A significant difference in values of UTS between different irradiation distances (F=225.71, $p<0.05$) and adhesive types (F=128.57, $p< 0.05$) with no significant interaction ($p>0.05$).

UTS of the total and self-etch adhesives significantly decreased with the increase of irradiation distance. Specimens irradiated directly (zero distances) have highest UTS while those irradiated at 4mm have the lowest values. Excite DSC has higher UTS than Clearfil S3 regardless of irradiation distance ($p<0.05$).

Table 1. Composition and manufacturer of adhesives used in this study.

Adhesive type	Manufacturer	Composition
Excite DSC (Total etch)	Ivoclar/vivadent, Schaan ,Lichtenstein	HEMA, phosphoric acid, acrylate, bis GMA, dimethacrylate, silica, catalysts, stabilizers, ethanol.
Clearfil S^3 (One step self-etch)	Kuraray Medical Inc., Tokyo, Japan	MDP, HEMA, bisGMA, dl-camphorquinone, water, ethanol, silanated colloidal silica.

Figure 1. Ultimate tensile strength of adhesives at different irradiation distances.



Different letters indicate significant difference in UTS between distances for each adhesive; different numbers indicate differences between adhesives at each distance.

DISCUSSION.

It is essential to avoid inferior physical properties of adhesives in the interface, to withstand the polymerization shrinkage of overlaying resin composite restoration. One way to enhance adhesive strength is through increased proximity of the light tip for better monomer conversion, mechanical properties and bond strength.[4]

Excite DSC and Clearfil S3 irradiated at different distances from the light source exhibited dissimilar UTS values, the greater the light tip distance the lower the UTS value.

Therefore the first hypothesis was rejected. This result is probably related to poor polymer network formation of adhesive resins as light distance increases from the material.[5] This result confirms the need of light exposure in close contact with the resin to possibly overcome significant decreases in monomer conversion percentages with an increase in light tip distance.[6]

The results from the comparison between two systems demonstrated a remarkable variation in their UTS means where the Excite DSC value was twice that of Clearfil S3 at every evaluated distance. Therefore, the second hypothesis that there is no difference between total etch and self-etch adhesives is also not accepted. These findings could be explained by the inherited differences in compositional percentage of water and organic solvent disclosed by the manufacturer and known as a result of simplification of all-in-one self-etch systems.

A study evaluated the conversion rate of total and self-etch adhesives under FTIR condition at three light irradiation distances (1mm, 3mm, and 6mm) and proved that total etch systems have a higher degree of monomer to polymer conversion in comparison with one-step self-etch adhesives.[7]

Another study conducted in situ utilizing Raman spectroscopy to evaluate polymerization behaviour within the adhesive layer with tooth structure found that Clearfil S3 with a water component exhibited a significant reduction ratio of degree of cure of the adhesive layer compared with Excite DSC without water.[8]

Moreover in a recent study Clearfil S3 demonstrated the lowest conversion percentage in comparison with three tested one-step self-etch adhesives.[9] The most extensively used solvent in Clearfil S3 bond is water. (Table 1)

Water is added to the mixture to generate the hydrogen ions essential for monomer ionization to demineralize tooth structure. Water is not miscible with some constituents of adhesive and its remnants affect mechanical quality. Clearfil S3 bond was prepared without attempt at water evaporation, therefore inferior UTS was expected than

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those total etch adhesives without a water content structure (*ie* DSC Excite).[3]

Water remnants within the resin might cause incomplete polymerization of Clearfil S3 adhesive beside the deleterious effect of water that may induce swelling and thus cause the reduction of the polymers mechanical properties by altering the mobility of their chain segments.

Furthermore Pucci *et al.,*[10] stated that Clearfil S3 bond exhibited a high water sensitivity during bonding procedures that significantly affected their bond strength results and the resin-dentine interface quality.

CONCLUSION.

The UTS of both systems was reduced when light irradiation distance increased.

UTS of the two adhesives was material dependant, with total etch system presenting twice the value of self-etch systems.

REFERENCES.

1. Ilie N, Stark K. Effect of different curing protocols on the mechanical properties of low-viscosity bulk-fill composites. Clin Oral Investig. 2015; 19(2):271-9.
2. Araújo-Neto VG, Nobre CFA, De Paula DM, Souza LC, Silva JC, Moreira MM, Picanço PRB, Feitosa VP. Glycerol-dimethacrylate as alternative hydrophilic monomer for HEMA replacement in simplified adhesives. J Mech Behav Biomed Mater. 2018;1(82):95-101.
3. Hosaka K, Nakajima M, Takahashi M, Itoh S, Ikeda M,Tagami J, et al. Relationship between mechanical properties of one-step self-etch adhesives and water sorption. Dent Mater. 2010; 26 (4):360–7.
4. Denis AB, Diagone CA, Plepis AM, Viana RB. The effect of the polymerization initiator and light source on the elution of residual Bis-GMA and TEGDMA monomers: A study using liquid chromatography with UV detection. Spectrochim Acta Mol Biomol Spectrosc. 2015; 5 (151): 908-915.
5. Rullman I, Patyna M, Janssen B, Willershausen B. Determination of polymerization shrinkage of different composites using a photoelastic method. Am J Dent. 2017; 30(1):16-22.
6. Filho JD, Poskus LT, Guimarães JGA, Barcellos AA, Silva EM. Degree of conversion and plasticization of dimethacrylate based polymeric matrices: influence of light-curing mode. J Oral Sci. 2008; 50(3): 315-321.
7. Maleknejad F, Ameri H, Manafi S, Chasteen J, Ghavamnasiri M. The effect of photoactivation time and light tip distance on the degree of conversion of light and dual-cured dentin adhesives. Indian J Dent Res. 2013; 24(2):225-8.
8. Sakano W, Nakajima M, Prasansuttiporn T, Foxton R and Tagami J. Polymerization behavior within adhesive layer of one- and two-step self-etch adhesives: A micro-Raman spectroscopic study. Dent Mater J. 2013; 32(6): 992–8.
9. Navarra CO, Cadenaro M, Frassetto A, Fontanive L, Di Lenarda R, Breschi L. Degree of Conversion of Self-etch Adhesives: In Situ Micro-Raman Analysis. Oper Dent. 2016; 41(5):501-510.
10. Pucci CR, Gu LS, Zeng C, Gou YP, Tay FR, Niu LN. Susceptibility of contemporary single-bottle self-etch dentine adhesives to intrinsic water permeation. J Dent. 2017;66:52-61.